

The figures in the margin indicate full marks.

All symbols have their usual meaning.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION - A

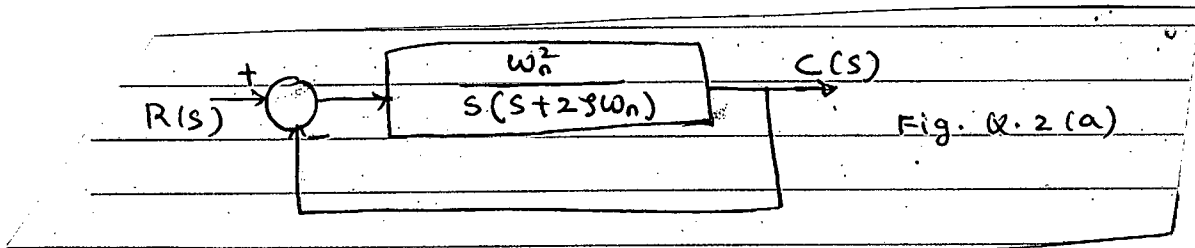
There are **FOUR** questions in this Section. Answer any **THREE**.

Semi-log Graph papers are to be supplied.

1. (a) State and explain Nyquist stability criterion For the following system shown in Fig. 1(a) determine whether the system is stable or unstable by sketching the complete Nyquist diagram. (10)
- (b) Define gain margin, gain cross-over frequency, phase margin, and phase cross-over frequency. Show these in two different frequency response plots for both stable and unstable systems. (10)
- (c) Evaluate the transfer function for the Bode plot shown in the Fig. 1(c). (15)

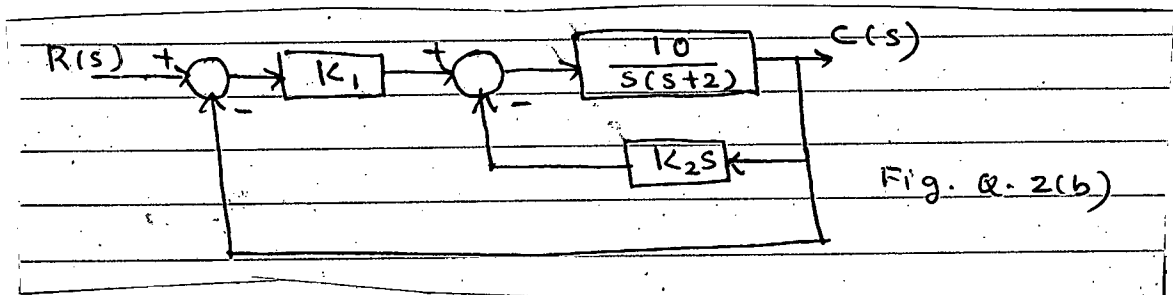
2. (a) The output response of the following system to a unit step input for $0 < \zeta < 1.0$ is $C(t)$

$$= 1 - \frac{e^{-\zeta\omega_n t}}{\sqrt{1-\zeta^2}} \left[\sqrt{1-\zeta^2} \cos \omega_{dt} + \zeta \sin \omega_{dt} \right].$$
 (15)



Find Rise time (t_r), Peak time (t_p), Percent Peak overshoot (M_p) and Settling time (T_s).

- (b) For the system of Fig. 2(b), find the values of K_1 and K_2 to yield a peak time of 1.5 second and a settling time of 3.2 seconds for the closed-loop systems step response. (10)



- (c) With a suitable example, explain the effect of adding third pole on the second order system response. (10)

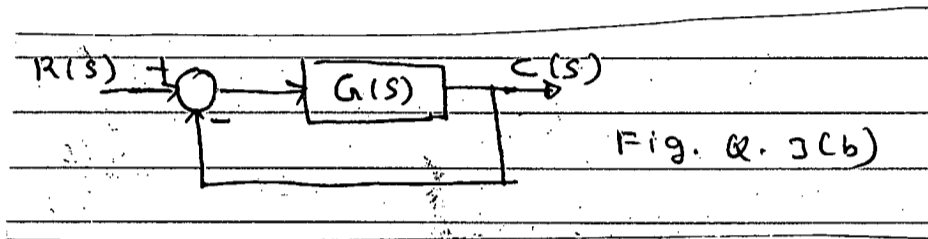
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3. (a) For a second order negative unity feedback control system, establish the relationship between the peak value of the closed loop magnitude response (M_m) and the damping ratio (ζ). Hence also find the -3 dB bandwidth in terms of settling time and damping ratio (ζ).

(15)

(b) The unity feedback control system shown in Fig. 3(b) with $G(s) = \frac{k}{(s+2)(s+5)(s+7)}$ is operating with 15% overshoot. Using frequency response methods design a compensator to yield five-fold improvement in steady state error without appreciably changing the transient response.

(20)



4. (a) Draw a signal-flow graph for the following state equations

$$\dot{X} = \begin{bmatrix} 7 & 1 & 0 \\ -3 & 2 & -1 \\ -1 & 0 & 2 \end{bmatrix} X + \begin{bmatrix} 1 \\ 2 \\ 1 \end{bmatrix} r, \quad Y = [1 \ 3 \ 2]X$$

Also find $\frac{Y(s)}{R(s)}$ using Mason's gain formula.

(17)

(b) A unity negative feedback control system has the following open loop transfer function

$$G(j\omega) = \frac{2}{j\omega(j\omega+1)(j\omega+2)}$$

(18)

The LM (dB) and the phase angle $\angle G(j\omega)$ at different frequencies are given in Table for 4(b)

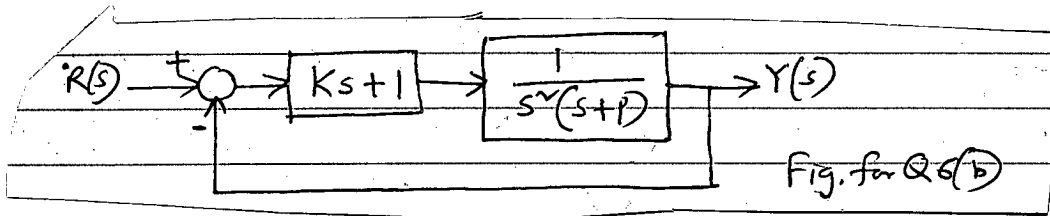
ω (rad/sec)	dB	$\angle G(j\omega)$ (degree)
0.2	14	-107
0.4	7	-123
0.6	3	-138
0.8	-1	-151
1	-4	-162
1.2	-7	-171
1.4	-9	180
1.6	-12	-187
1.8	-14	-193
2.0	-16	-198

Using Nichol's chart find (i) Gain margin, phase margin and gain cross-over frequency. (ii) Peak value of the closed loop magnitude response and peak frequency. Is the system stable or unstable? (Attach the used Nichol's chart with your answer script).

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Contd ... Q. No. 6

(b) A closed-loop feedback system is shown in Fig. for Q. 6(b)



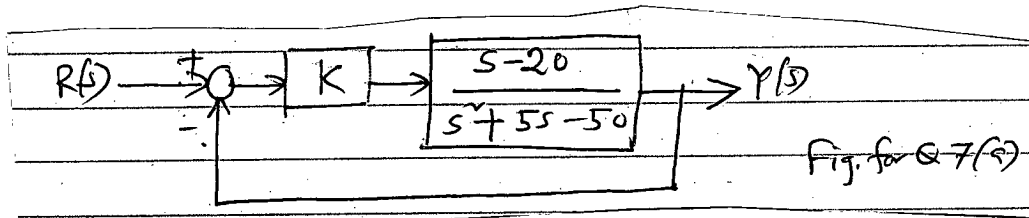
Find the range of values of the parameters K and P for which the system is stable. (11)

(c) The characteristic equation of a negative feedback system is

$$1 + \frac{Ks(s+4)}{s^2 + 2s + 2} = 0$$

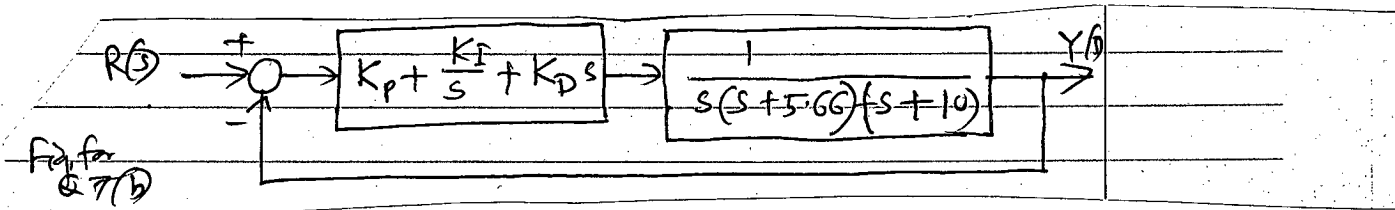
Sketch the root locus. Find the gain K when both the closed-loop roots are equal. (12)

7. (a) Consider the system shown in Fig. for Q. 7(a).



Sketch the root locus for $-\infty < k \leq 0$. Comment on the stability of the system for negative gain K. (11)

(b) Consider the closed loop system shown in Fig. for Q. 7(b).



Sketch the root locus for $K_p = 370$, $K_I = 0$, and $0 \leq K_p < \infty$. (12)

(c) A unity feedback system with the forward transfer function

$$G(s) = \frac{K}{s(s+7)}$$

is operating with a closed loop step response that has a 15% overshoot. Evaluate the steady-state error for a unit ramp input. Design a lag compensator to improve the steady-state error by a factor of 20. (12)

8. (a) Consider a unity feedback system with forward transfer function

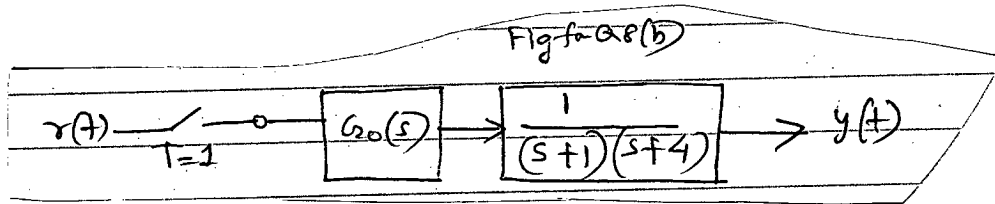
$$G(s) = \frac{K}{(s+5)^3}$$

Design a lead compensator to operate the system with 1.2 sec settling time and 15% overshoot. The compensator zero is placed at -1 and you can apply second order approximation. (15)

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Contd ... Q. No. 8

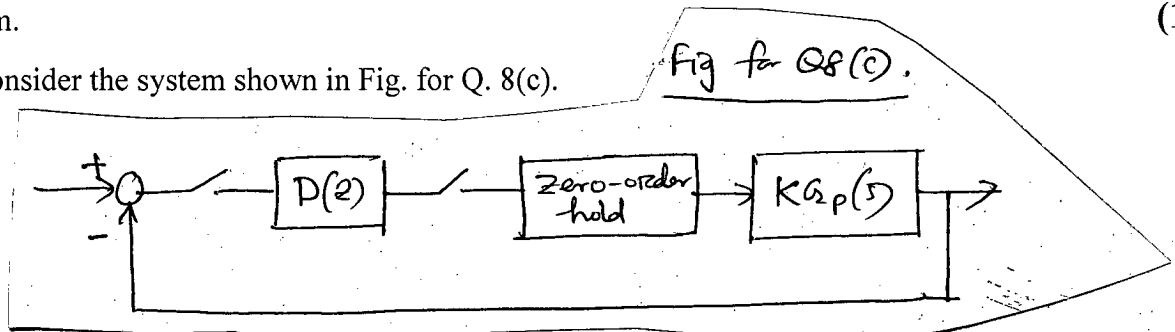
(b) Consider the open loop sampled-data system shown in Fig. for Q. 8(b).



$G_0(s)$ denote a zero-order-hold system. Determine the transfer function $G(z)_x$ for sampling time $T=1$ sec. Discuss the effect of T on stability and transient response of the system.

(10)

(c) Consider the system shown in Fig. for Q. 8(c).



Where $G_p(s) = \frac{20}{s(s/2+1)}$ and we want a phase margin of 45° . A suitable analog

compensator for this system is $G_c(s) = \frac{1+6.66s}{1+66.6s}$

Obtain the digital controller $D(z)$ if $T = 0.001$ s.

(10)

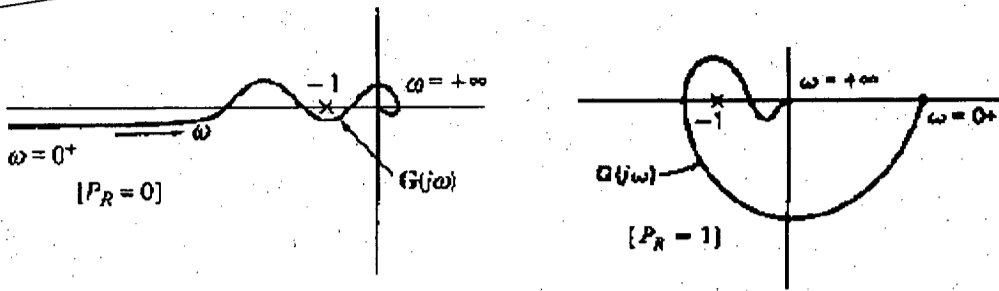


Fig. 507 (a)

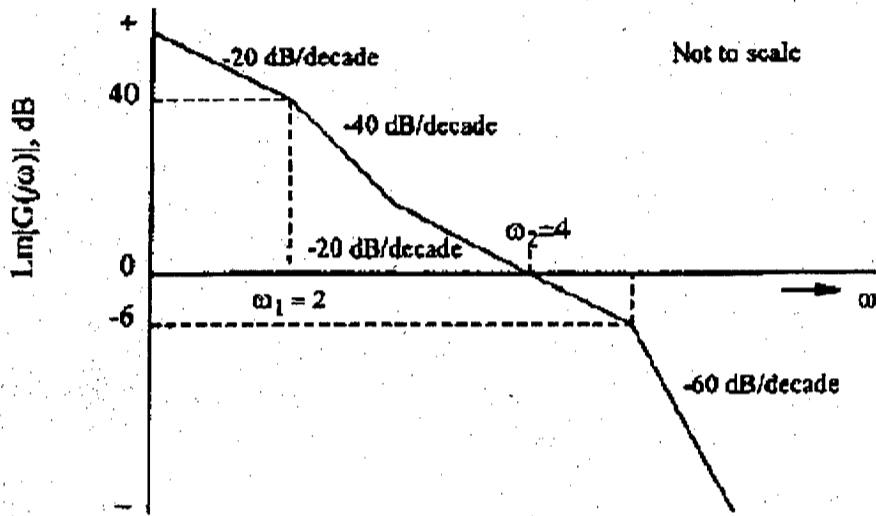
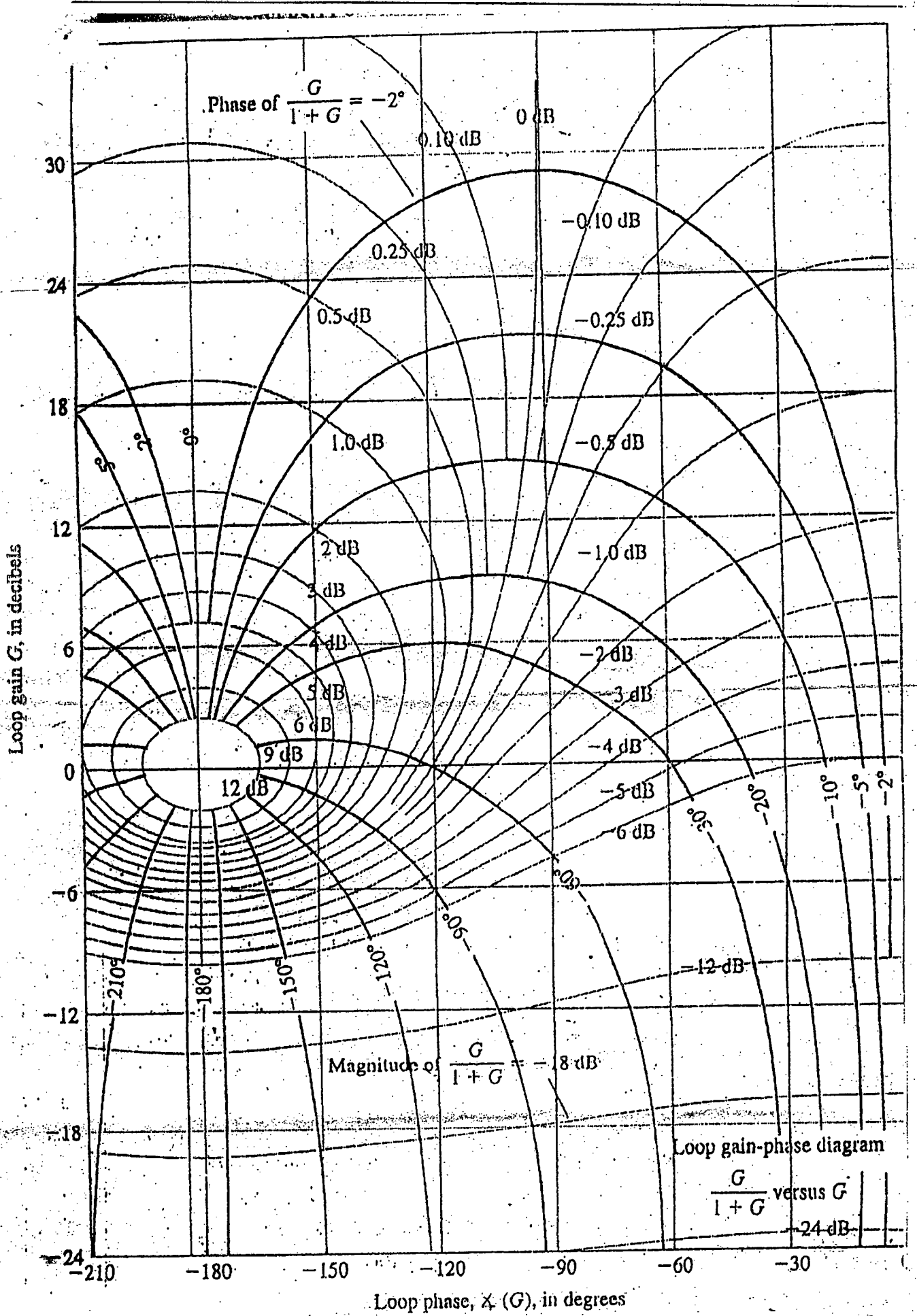


Fig. 507 (c)



Nichols chart for $\alpha = 4 \text{ (b)}$

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2017-2018

Sub : **EEE 451** (Processing and Fabrication Technology)

Full Marks : 210

Time : 3 Hours

The figures in the margin indicate full marks.

Symbols have their usual meanings.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this Section. Answer any **THREE**.

1. (a) Explain the effect of thermal oxidation on impurity distribution in Si and SiO₂, in case of $m < 1$ and $m > 1$, where m has its usual meaning. Explain the application of silicon oxynitrides. (12+8)
- (b) Assume that O_2^- has exactly twice the diffusion coefficient in SiO₂ as neutral O₂, but 10 times the reactivity in surface, with exactly the same activation energy for the reaction rate coefficient. Now if an oxidation is carried out at 1000°C in a source of 1 atm of O_2^- , calculate the oxidation time for a 1000-Å gate oxide. Assume no initial oxide, A is 0.165 μm, $B = 0.0117 \mu\text{m}^2/\text{hr}$, $\tau = 0.37 \text{ hr}$ for 1000°C dry ambient. (15)
2. (a) Describe the two-color pyrometry technique. Compare between tungsten-halogen lamps and discharge lamps as high-intensity optical sources for RTP processes. (10+10)
- (b) Using Fair's vacancy model including charge effects, calculate D of As in Si at 1000°C. Concentration for As is 10^{21}cm^{-3} . What would happen, if this concentration reduces to 10^{15}cm^{-3} ? What would happen if charge effects are not included? [Given: $D_0^- = 12$, $E_a^- = 4.05$, $D_0 = 0.066$, $E_a = 3.44$]. (15)
3. (a) Explain, briefly, the various nucleation mechanisms. Explain the CUD growth process in details. (8+12)
- (b) Briefly explain the following processes/manifolds: (5+5+5)
drive-in, RIE, gas handling system
4. (a) What are the limitations of Hall effect measurement (Van der Pauw technique)? What is the RCA recipe for wafer cleaning? What are the differences between ICP and ECR plasma sources? (7+7+7)
- (b) Briefly explain, the growth sequences of a MQW structure. What differences can there be between MQW structures grown in MBE than those grown in MOCVD? (7+7)

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SECTION – B

There are **FOUR** questions in this Section. Answer any **THREE** questions.

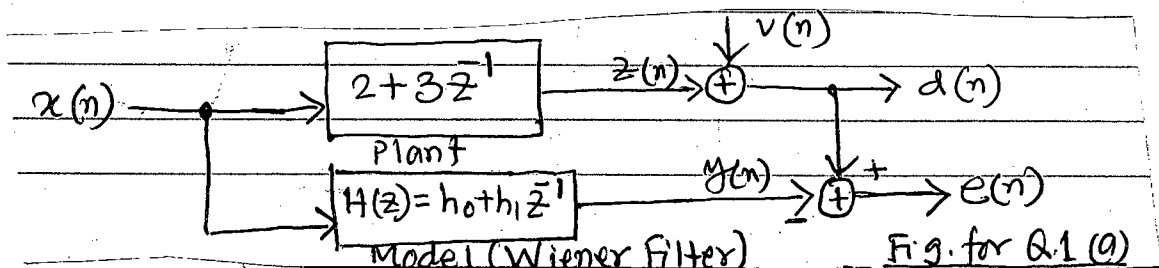
5. (a) What are the steps in photomasking? Explain aligner selection criteria. Classify aligner systems. What uses are for alignment marks? Give examples. **(20)**
- (b) Compare between positive and negative photoresists. Describe dynamic spin dispensing technique. **(15)**
6. (a) What are the various physical vapor deposition process? Explain briefly. **(20)**
- (b) Throughout microelectronic processing steps, wafers spend multiple/prolonged hours in wafer rinse systems. What contaminants can there be in such wafer systems and how DI water can help them reduce such problems? Show schematic of a typical DI water system. **(15)**
7. (a) Why is wafer priming important? With necessary diagrams briefly explain various priming methods. **(20)**
- (b) What are the different cleanroom classes according to air cleanliness? Discuss with suitable diagrams, soft bake and hard bake processes and make comparison. **(15)**
8. Write short notes on the following topics: **(9+9+9+8)**
- (a) Colloidal lithography
- (b) Electro Deposition of Photoresist
- (c) Non optical lithography
- (d) Channeling.
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The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – AThere are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Consider the modeling problem shown in Fig. for Q. No. 1(a). The plant is a two-tap filter with an additive white noise, $v(n)$, added to its output. A two-tap Wiener filter with tap weights h_0 and h_1 is used to model the plant parameters. The input, $x(n)$, is a stationary white process with variance of unity. The additive noise, $v(n)$, is zero-mean and uncorrelated with $x(n)$, and its variance is $\sigma_v^2 = 0.1$. Compute the optimum values of h_0 and h_1 , which minimize $J = E\{e^2(n)\}$. Also calculate J_{\min} for the optimum weights. (20)



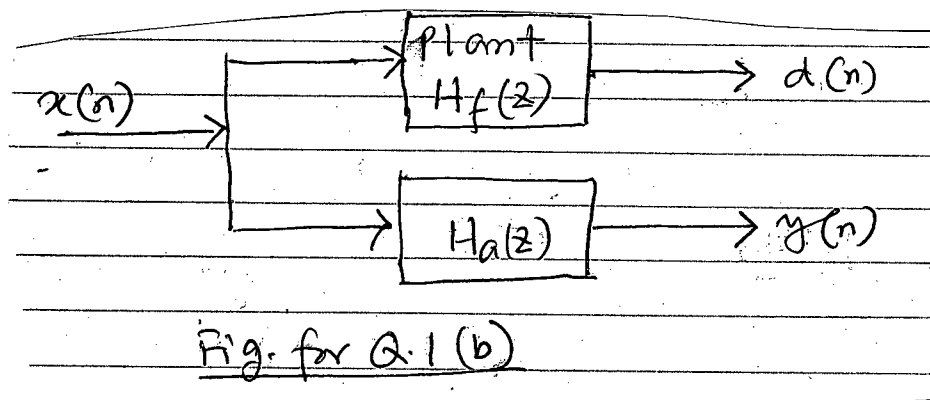
- (b) Consider the system identification problem shown in Fig. for Q. 1(b). The adaptive filter that is used to model $H_f(z)$ has two free parameters, a and b , as in the following: (15)

$$H_a(z) = \frac{b}{1 - az^{-1}}$$

The input, $x(n)$, to both systems is unit variance white noise, and the goal is to find the values of a and b that minimize the cost function

$$J(n) = \sum_{i=0}^n \lambda^{n-i} |e(n)|^2, \quad 0 < \lambda < 1$$

where $e(n) = d(n) - y(n)$. Defining all the quantities as required, summarize the RLS adaptive filter algorithm for this problem.



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2. (a) Consider the channel equalization problem in Fig. for Q. 2(a). The data symbols, $s(n)$ are assumed to be samples of a stationary white process with variance $\sigma_s^2 = 3$. (20)
- (i) Find the correlation matrix \mathbf{R} of the equalizer tap inputs and the cross-correlation vector \mathbf{P} between the equalizer tap inputs and the desired output.
- (ii) Find the tap weights of the equalizer using the steepest descent method for iteration index $n = 1, 2$, and 3 . Assume that step-size $\mu = \frac{1}{6}$ and $\mathbf{W}(0) = [0.5 \ 0]^T$.

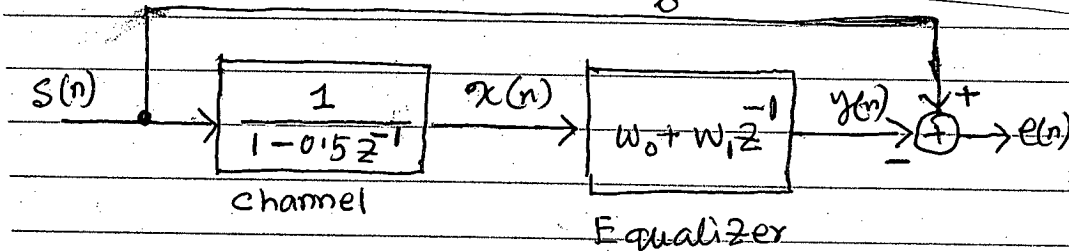


Fig. for Q. 2 (a)

- (b) Consider the time-varying cost function (15)

$$J(n) = |e(n)|^2 + \alpha \|W(n)\|^2$$

Where $W(n)$ is the tap-weight vector of an FIR filter, $e(n)$ is the estimation error, and α is a constant. As usual

$$e(n) = d(n) - W^H(n) x(n)$$

Where $d(n)$ is the desired signal and $x(n)$ is the tap-input vector. Show that the time update for the tap-weight vector, using the LMS algorithm, can be obtained as $W(n+1) = (1 - \mu\alpha)W(n) + \mu x(n) e^*(n)$ where μ denotes the step-size.

3. The analysis filter $H_0(z)$ in a two-channel QMF has the transfer function (35)

$$H_0(z) = 1 + z^{-1}$$

- (a) Determine the polyphase filters $E_0(z^2)$ and $E_1(z^2)$.
- (b) Determine the analysis filter $H_1(z)$ and sketch the two-channel analysis section that employs polyphase filters.
- (c) Determine the synthesis filters $G_0(z)$ and $G_1(z)$ and sketch the entire two-channel QMF based on polyphase filters.
- (d) Show that the QMF bank results in perfect reconstruction.

4. (a) A digital audio system exploits over-sampling techniques to relax the requirements of the analog anti-imaging filter. The overall filter specifications for the system is given below: (20+10+5)

base band	0-20 KHz
input sampling frequency, F_s	44.1 KHz
output sampling frequency	176.4 KHz
Stopband attenuation, δ_s	0.00316
passband ripple, δ_p	0.0592
transition width	2 KHz
stopband edge frequency	22.05 KHz

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Design, at a block diagram level, a two-stage interpolator for this problem. Compare MPS and TSR of this two-stage implementation with that of a single-stage interpolator.

(b) A sequence $x(n)$ is up sampled by $L = 2$, it passes through an LTI system $H_1(z)$, and then it is down sampled by $M = 2$. Can we replace this process with a single LTI system $H_2(z)$? If the answer is positive, determine the system function of this system.

(c) Show that the following FIR filter transfer function, $H(z)$, is a half-band filter:

$$H(z) = -3 + 19z^{-2} + 32z^{-3} + 19z^{-4} - 3z^{-6}$$

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

Symbols and abbreviation have their usual meanings.

5. (a) Develop the filter bank interpretation of the inverse DWT. Comment on the practical requirement of stability for the inversion.

(b) Briefly explain vanishing moment and admissibility criterion for a wavelet. Show that a Haar wavelet satisfies the admissibility criterion where it is given by

$$\psi(\omega) = \sin^2\left(\frac{\omega}{4}\right) / \left(\frac{\omega}{4}\right), \quad -\infty < \omega < \infty$$

6. (a) The signal $y(n)$ consists of complex exponentials in white noise. The auto correlation

matrix is given by $T_{yy} = \begin{bmatrix} 2 & -j & 1 \\ j & 2 & -j \\ -1 & j & 2 \end{bmatrix}$

Determine the frequencies and powers of the complex exponential.

(b) Briefly explain the filter bank implementation of a periodogram. Is this representation adaptive to the data?

7. (a) The input-output relationship of an LTI system is given by $y(n) = 0.6 y(n-1) + x(n) + x(n-1) + x(n-2)$ where the input $x(n)$ has zero mean and auto correlation

$$\gamma_{xx}(m) = \left(\frac{1}{2}\right)^{|m|} + \delta(m)$$

Determine (i) power density spectrum of $y(n)$, (ii) $\gamma_{yy}(m)$ and (iii) σ_y^2 .

(b) Briefly discuss the various criteria for selecting the order of an AR model.

8. (a) An AR (2) process is expressed as $x(n) = 0.81x(n-2) + W(n)$ where $W(n)$ is a white noise process with variance σ_w^2 . Determine the parameters of the MA(4) model providing a minimum mean square error fit to the data $x(n)$.

(b) Show that the periodogram is not a consistent estimate of the true power density spectrum of a random process.

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2017-2018

Sub : **EEE 471** (Energy Conversion-III)

Full Marks : 210

Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – AThere are **FOUR** questions in this Section. Answer any **THREE**.

1. (a) Explain the construction of hybrid stepper motor. Explain its operation by using a bifilar, 2-phase, 2-pole per phase stepper motor with rotor having 9 teeth on each of the end discs. With diagram explain the operation of multistack variable reluctance stepper motor. (17)
- (b) Explain with diagram how a permanent magnet and single stack variable reluctance motor operate. Why the angle resolution of permanent magnet stepper motor cannot be made high? What should be the number of phases of single stack variable reluctance stepper motor? Why variable reluctance stepper motor with 8/6 pole construction has higher torque than 6/8 pole construction? (18)
2. (a) Draw the torque versus pulse per second (PPS) characteristic of stepper motor and show on it start, slew and pull-out ranges. What are the holding torque, detent torque and pull-out torque of stepper motor? Why PPS response rate of variable reluctance stepper motor is better than permanent magnet stepper motor? (17)
- (b) Explain the bifilar winding of hybrid stepper motor. Draw the drive circuit of stepper motor with bifilar winding and explain its operation. Draw different configurations for drive circuits for switching the phase windings and explain how they work. Mention for which type of stepper motor they are used. (18)
3. (a) What are the distinctive differences between switched reluctance motor and conventional reluctance motor? Draw the $L-\theta$ profile of a switched reluctance motor and explain how switching angle is controlled at starting, low speed, medium speed and high speed of the motor. Explain how rotor position sensing is done by Hall effect probe. (17)
- (b) (i) A stepper motor has a step angle of 1.8° and is driven by 4000 PPS. Determine resolution in steps/revolution, motor speed and number of pulses required to rotate the shaft through 54° . (6)
- (ii) Find the step angle of 3-phase, 6/4 switched reluctance motor and determine its speed when frequency of switching of each phase is 500 Hz. (6)
- (iii) What is the required resolution in steps/revolution for a stepper motor that is to operate at a pulse frequency 6000 PPS and travel 180° in 0.025 sec. (6)

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4. (a) With necessary diagram explain how a brushless dc motor (BLDM) operates. What are the advantages of interior magnet construction of rotor over the surface mounted magnet construction? (17)
- (b) Explain how linear induction motor works. Describe different types of linear induction motor. With diagram explain how it can be used for driving belt conveyors and electric traction systems. What is magnetic levitated (MAGLEV) electric vehicle? (18)

SECTION – B

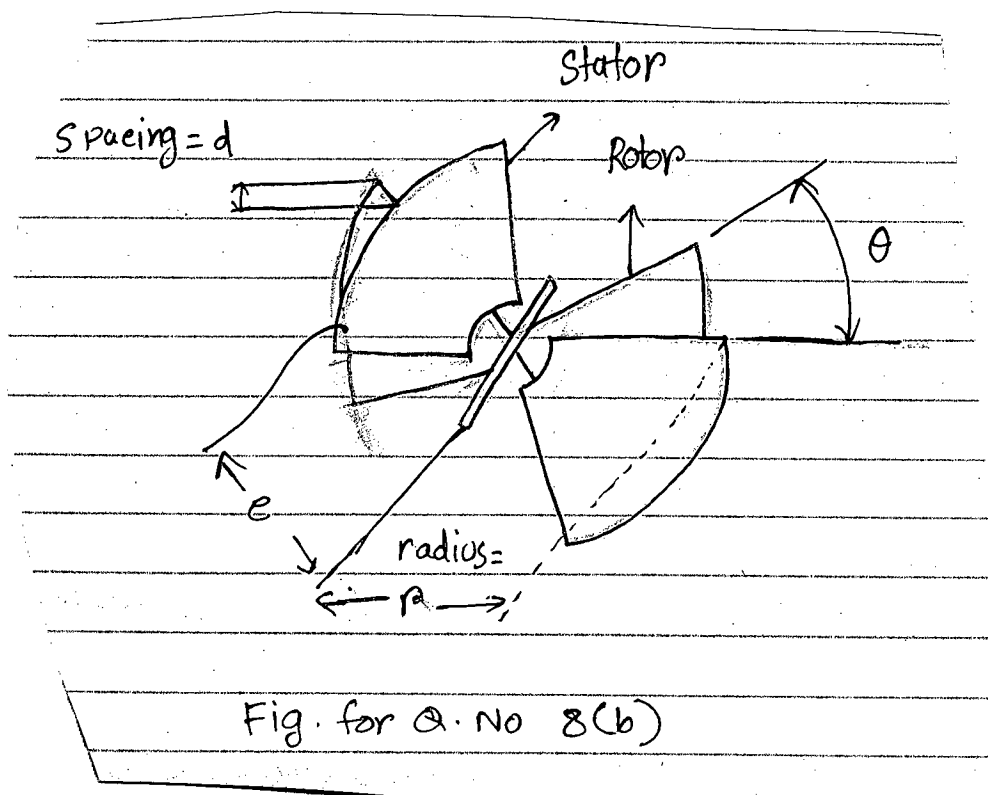
There are **FOUR** questions in this Section. Answer any **THREE** questions.

5. (a) Discuss the demagnetization effect on air gap flux in a permanent magnet DC (PMDC) Motor. (20)
- (b) Write down the control algorithm to control a Universal motor with phase angle drive. (15)
6. (a) What is the basic difference between a Repulsion motor a Reluctance motor in terms of method of developing torque. (5)
- (b) Direction of rotation of a Repulsion motor can be reversed both mechanically and electrically-Describe. (15)
- (c) A 50 Hz hysteresis motor possesses 32 poles. In making one complete turn with respect to the revolution field, the hysteresis loss in the rotor amount to 0.8 J. Calculate- (15)
- (i) the hysteresis torque
 - (ii) the maximum power output before the motor stall
 - (iii) the rotor losses when the motor is stalled
 - (iv) the rotor losses when the motor runs at synchronous speed.
7. (a) With necessary diagram explain the principle of a thermo electric DC conduction pump. (15)
- (b) Metadyne can act as a constant current generator- explain. (15)
- (c) The output terminal voltage of both DC Generator and Acyclic Generator is DC. Then what is the distinguishing feature of an Acyclic Generator. (5)
8. (a) With necessary schematic diagram discuss the working principle of an open magneto-hydro-dynamics (MHD) Generation cycle. (10)
- (b) For the rotating electrostatic machine shown in Fig. for Q. No. 8(b), the rotor and stator axes are coincident at $\theta = 0$. The rotor and stator sectors are complete quarter circular disks and the thickness of each plate is negligible in comparison with the spacing(d) between the plates. Find- (25)

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Contd ... Q. No. 8(b)

- (i) the maximum capacitance between rotating and stationary plates.
- (ii) Derive an approximate expression for the capacitance between the stationary and rotating plates as a function of angular displacement. Express the capacitance as a Fourier series.
- (iii) If a voltage $e = \hat{E} \cos \omega t$ volts is applied between the plates, then derive the expression of Torque if angular velocity of rotor is ν radians/second and initial angular position $\theta = -\delta$.
- (iv) What is the condition for a non zero average torque and find out that torque.
- (v) What is the condition for maximum torque and find out the maximum torque that can be achieved from the machine?



SECTION – A

There are **FOUR** questions in this Section. Answer any **THREE**.

‘List of Equations’ attached

1. (a) A n-type semiconductor has a bandgap of 1.4 eV and electron and hole effective masses of $0.2 m_0$ and $1.2 m_0$ respectively. At any temperature above 200 K, all dopant atoms in the semiconductor are ionized. (20)
- (i) For a doping concentration of 10^{15} cm^{-3} , calculate the thermal equilibrium electron and hole concentrations in the semiconductor at a temperature of $T = 300 \text{ K}$
- (ii) If the semiconductor is considered non-degenerate when the Fermi level is $3kT$ energy below the conduction band edge, calculate the doping concentration at which the semiconductor becomes degenerate
- (iii) Assuming an initial doping concentration of 10^{16} cm^{-3} , calculate the temperature above which the semiconductor becomes intrinsic.
- (b) A p-type semiconductor in thermal equilibrium has the following doping profile: $N_d(x) = N_{d0} \exp(-\beta x)$, where $0 \leq x \leq 1/\beta$ and N_{d0} is a constant. (15)
- (i) Calculate the electric field inside the semiconductor as a function of x
- (ii) Calculate the potential difference between $x = 0$ and $x = 1/\beta$
- (iii) If the intrinsic carrier concentration of the semiconductor is n_i , under thermal equilibrium condition derive the expressions of electron and hole diffusion current densities as a function of position over the given range. What will be the electron and hole drift current densities in this semiconductor at thermal equilibrium?
2. (a) At 300 K, a compensated doped semiconductor has fully ionized acceptor and donor doping concentrations of 10^{16} cm^{-3} and $3 \times 10^{16} \text{ cm}^{-3}$ respectively. At zero applied bias, excess carriers are generated instantaneously at time $t = 0$, and position $x = 0$ because of photoexcitation. The photoexcitation is turned off immediately so that the generation rate becomes zero after $t > 0$. Assume the semiconductor to be homogenous and of infinite extent, obtain the following. (20)
- (i) Expressions of excess electron and hole concentrations in the semiconductor as a function of position.
- (ii) If the intrinsic carrier concentration of the semiconductor is 10^{15} cm^{-3} , calculate the energy difference between the Fermi level and the quasi Fermi levels at $x = 20 \mu\text{m}$, given

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Contd ... Q. No. 2(a)

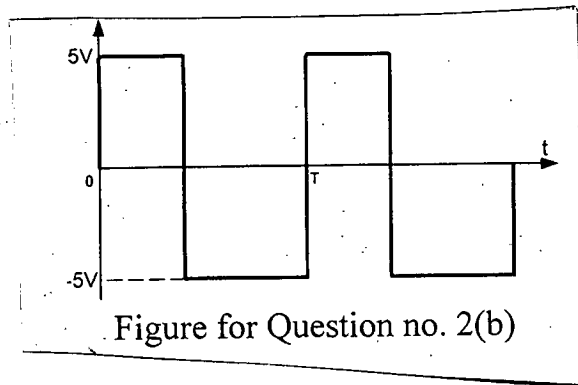
that the generation rate at $x = 0$ was $5 \times 10^{21} \text{ cm}^{-3}$, the minority carrier lifetime is 10^{-7} s and mobility of minority carriers in the semiconductor is $1300 \text{ cm}^2/\text{V-s}$ at $T = 300 \text{ K}$

(iii) Graphically show the electron concentration profile as a function of position for different times if a positive electric field is applied to the semiconductor

(b) Consider a n^+p diode connected in series with a $5 \text{ k}\Omega$ resistor and a high frequency square wave source (waveshape shown in the Fig. for Q. 2(b)). The built in voltage of the diode is 0.7 V and under forward bias, the diode current is 2 mA . If the reverse saturation current of the diode is $0.5 \mu\text{A}$ and the minority carrier lifetime is 100 ns , obtain the following.

(15)

- (i) Storage delay time of the diode under the mentioned high-frequency operation
- (ii) For $t \ll T/2$, plot the electron distribution in the p-region for increasing time
- (iii) Plot the current in the circuit and the voltage across diode as a function of time (clearly label all values on both plots)



3. (a) Consider a p-n junction at $T = 300 \text{ K}$ with doping concentration of 10^{16} cm^{-3} and 10^{17} cm^{-3} respectively. The intrinsic carrier concentration and relative dielectric constant of the diode material are $2 \times 10^{10} \text{ cm}^{-3}$ and 12 respectively. For an applied bias, the overall potential drop across the contact regions of the diode is 1.2 V .

(17)

- (i) Calculate the space charge widths in the p--and n-regions of the diode under a forward bias voltage of 2V
- (ii) Taking potential at the p-region as the reference, calculate the potential drop at the metallurgical interface of the p-n junction for the above forward bias voltage
- (iii) What is the reverse bias voltage required to obtain a peak electric field of 10^5 V/cm in the junction region?

(b) Graphically show the following:

(10)

- (i) Position of Fermi level as a function of donor concentration in a semiconductor for temperatures T_1, T_2 and T_3 where $T_3 > T_2 > T_1$
- (ii) Electron concentrations vs. temperature in a n-type semiconductor for doping concentrations N_1, N_2 and N_3 where $N_3 > N_2 > N_1$ (Clearly indicate extrinsic and intrinsic regions on your plot)

EEE 413

Contd ... Q. No. 3

(c) How donor and acceptor activation energies are related to 'full ionization' and 'freeze-out' conditions? Indicate these energies in an energy band diagram with respect to donor and acceptor states. (8)

4. (a) Derive the expression of minority carrier distribution profiles in a p-n junction diode. Use these expressions to obtain the following for a forward bias voltage of 0.9 V (required parameters for calculation are listed below) (20)

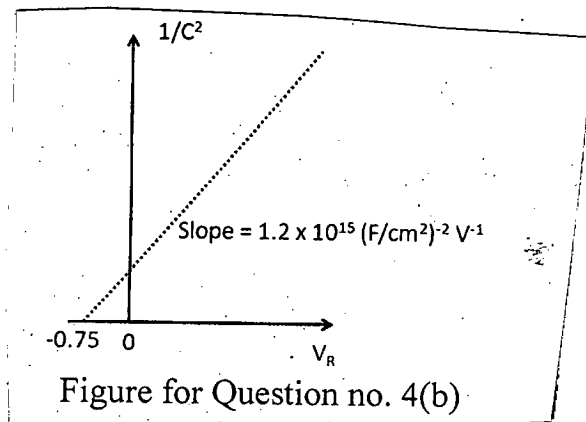
(i) Diffusion current densities at the two edges of the depletion region of the diode at an applied forward bias of 0.9 V

(ii) Majority hole current density at $x = 0.2 \mu\text{m}$ away from the depletion region of the diode

(iii) Reverse saturation current density of the diode and also the total current density flowing through the diode at this forward bias

Relevant parameters: $N_a = N_d = 10^{16} \text{ cm}^{-3}$; $n_i = 10^{10} \text{ cm}^{-3}$; $D_n = 25 \text{ cm}^2/\text{v-s}$; $D_p = 15 \text{ cm}^2/\text{V-s}$; $\tau_{p0} = \tau_{n0} = 6 \times 10^{-7} \text{ s}$; $\epsilon_r = 11.5$.

(b) The $1/C^2$ vs. V_R plot of a p^+n junction is shown in the figure below, where C is the junction capacitance and V_R is the applied reverse bias voltage of the diode. If the intrinsic carrier concentration and relative dielectric constant of the diode material are $3 \times 10^{10} \text{ cm}^{-3}$ and 11.5 respectively, obtain the doping concentrations of both regions of the diode. Also calculate the space charge densities in both n and p sides of the diode. (15)



EEE 413

SECTION – B

There are **FOUR** questions in this Section. Answer any **THREE** questions.

5. (a) Draw the energy band diagram for metal-Semiconductor junction for the following two cases- (7+7+4)

- (i) Schottky barrier diode for metal-n-semiconductor junction
- (ii) Ohmic contact for metal-p-semiconductor junction.

Why one is rectifying and the other one is non-rectifying?

- (b) For a contact between tungsten and n-type silicon, the following parameters are given $N_d = 10^{16} \text{ cm}^{-3}$, $N_c = 2.8 \times 10^{19} \text{ cm}^{-3}$, $\phi_m = 4.55 \text{ V}$ (tungsten), $\chi = 4.01 \text{ V}$ (silicon), $T = 300^\circ \text{ K}$.

Find the barrier height, built in potential barrier and maximum electric field in the junction for zero applied bias. (17)

6. (a) Draw the energy band diagram of a pnp transistor in forward active mode. (8)

- (b) Draw a diagram showing the current density components in an npn transistor working in forward active mode. (10)

- (c) A silicon npn transistor is uniformly doped and biased in the forward active region. The neutral base widths is $X_B = 0.8 \mu\text{m}$. The transistor doping concentrations are $N_E = 5 \times 10^{17} \text{ cm}^{-3}$, $N_B = 10^{16} \text{ cm}^{-3}$ and $N_C = 10^{15} \text{ cm}^{-3}$ (17)

- (i) Calculate the values of P_{EO} , n_{BO} and P_{CO}

- (ii) For $v_{BE} = 0.625 \text{ V}$, determine n_B at $x = 0$ and P_E at $x' = 0$.

Given $n_i = 1.5 \times 10^{10} \text{ cm}^{-3}$ and $T = 300^\circ \text{ K}$.

7. (a) Consider a uniformly doped silicon BJT with a metallurgical base width of $0.5 \mu\text{m}$ and a base doping of $N_B = 10^{16} \text{ cm}^{-3}$. The punch-through voltage has to be $V_{PT} = 25 \text{ V}$. What should be the collector doping and collector width to meet the punch-through voltage specification? Given $\epsilon_{si} = 11.7$ (relative) (20)

- (b) Briefly describe the following non-ideal effects for BJT (15)

- (i) Base-width modulation
- (ii) Emitter bandgap narrowing

8. (a) For a MOS device with n+ polysilicon gate and a p type silicon substrate the following parameters are given

$N_a = 3 \times 10^{16} \text{ cm}^{-3}$	$N_i = 1.5 \times 10^{10} \text{ cm}^{-3}$
$Q'_{SS} = 10^{10} \text{ cm}^{-2}$	$T = 300^\circ \text{ K}$
$\phi_{ms} = -1.13 \text{ V}$	$\epsilon_{ox} = 3.9$ (relative)
$t_{ox} = 500 \text{ \AA}$	$\epsilon_{Si} = 11.7$ (relative)

Find the threshold voltage for the device. (20)

EEE 413**Contd ... Q. No. 8**

(b) For a n-channel MOSFET, the following parameters are given

$$L = 1.25 \mu\text{m}$$

$$\mu_n = 650 \text{ cm}^2/\text{V-s}$$

$$C_{\text{ox}} = 6.9 \times 10^{-8} \text{ F/cm}^2$$

$$V_T = 0.65 \text{ V}$$

What should be the channel width, w such that $I_D(\text{sat}) = 4 \text{ mA}$ for $V_{GS} = 5 \text{ V}$. Is this device depletion mode or enhancement mode?

(15)

List of Equations

(Different terms in these equations have their corresponding meanings)
usual

$$N_v = 2 \left(\frac{2\pi m_p^* kT}{h^2} \right)^{3/2}$$

$$N_c = 2 \left(\frac{2\pi m_n^* kT}{h^2} \right)^{3/2}$$

$$E = -V_t \frac{1}{N} \frac{dN}{dx}$$

$$D_p \frac{\partial^2 p}{\partial x^2} - \mu_p \left(E \frac{\partial p}{\partial x} + p \frac{\partial E}{\partial x} \right) + g_p - \frac{p}{\tau_p} = \frac{\partial p}{\partial x}$$

$$D_n \frac{\partial^2 n}{\partial x^2} - \mu_n \left(E \frac{\partial n}{\partial x} + n \frac{\partial E}{\partial x} \right) + g_n - \frac{n}{\tau_n} = \frac{\partial n}{\partial x}$$

$$\phi(x) = \frac{eN_d}{\epsilon_s} \left(x_n x - \frac{x^2}{2} \right) + \frac{eN_a}{2\epsilon_s} x_p^2$$

$$x_n = \left\{ \frac{2\epsilon_s V_{bi}}{e} \left(\frac{N_a}{N_d} \right) \left(\frac{1}{N_a + N_d} \right) \right\}^{1/2}$$

$$x_p = \left\{ \frac{2\epsilon_s V_{bi}}{e} \left(\frac{N_d}{N_a} \right) \left(\frac{1}{N_a + N_d} \right) \right\}^{1/2}$$

$$C = \left\{ \frac{e\epsilon_s N_a N_d}{2(V_{bi} + V_R)(N_a + N_d)} \right\}^{1/2}$$

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2017-2018

Sub : **EEE 455** (Compound Semiconductor and Hetero-Junction Devices)

Full Marks : 210

Time : 3 Hours

The figures in the margin indicate full marks.

All the symbols used have their usual meanings.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – AThere are **FOUR** questions in this Section. Answer any **THREE**.

1. (a) With a very brief description and illustration (where necessary), explain the following terms: (answer any three) (12)
- (i) Elementary, binary and ternary semiconductor
 - (ii) Diamond lattice
 - (iii) Zincblende lattice
 - (iv) Growth of epitaxial layer
- (b) Differentiate between the direct bandgap and indirect bandgap semiconductors. Draw the electron mobility versus minimum bandgap curve for some common direct bandgap and indirect bandgap semiconductors. (14)
- (c) The following table shows the variation of drift velocity of electron inside InP with respect to electric field. Use this table to answer the following questions: (9)
- (i) value of critical electric field
 - (ii) value of drift velocity at overshoot
 - (iii) range of electric field where differential mobility is negative

Electric Field (kV/cm)	Drift Velocity (10^7 cm/s)
0.00	0.00
5.00	1.25
10.00	2.30
14.00	2.50
20.00	2.35
30.00	1.80
40.00	1.40
50.00	1.25
60.00	1.20
70.00	1.20

2. (a) Define staggered, straddling and broken gap heterojunctions. Give one example of each type and mention the approximate band gap energy. (9)
- (b) A wide bandgap p-type material and a narrow bandgap n-type material are used to form a heterojunction. Draw the energy band diagram of the system at thermal equilibrium after the materials are brought into contact. Also sketch the following: (8+18)
- (i) Electric field in both regions
 - (ii) Electrostatic potential along the junction
 - (iii) Space charge width in both regions

EEE 455

3. (a) Sketch the energy-band diagram of a metal-semiconductor junction with an interfacial layer and interface states. Compare the $I-V$ characteristic of a pn junction diode and that of a Schottky barrier diode. (15)
- (b) Mention the name of various 'band offsets prediction models'. Draw the linear superposition of atomic-like potential proposed by Kroemer that can determine relative alignment of two periodic potentials of two semiconductors. (10)
- (c) Calculate the space charge width for a Schottky barrier on a heavily doped semiconductor. Consider silicon at $T = 300$ K doped at $N_d = 7 \times 10^{18} \text{ cm}^{-3}$. Assume a Schottky barrier with $\phi_{Bn} = 0.67$ V. Assume that $V_{bi} = \phi_{B0}$ and neglect the barrier lowering effect. (10)
4. (a) Draw the internal structure of a MESFET and give a brief operational features of this device. (13)
- (b) In reference to the graphs shown in Fig. for the Q. No. 4(b), explain what happens to the optical characteristics of a material after the crossover point of alloy composition (x). (7)

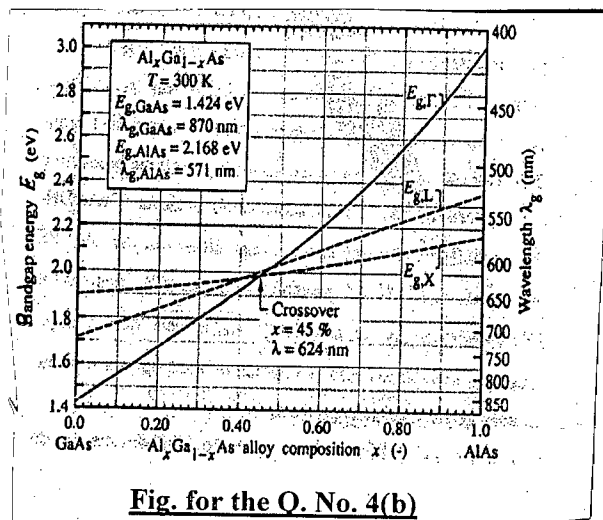


Fig. for the Q. No. 4(b)

- (c) Draw the small signal equilibrium circuit of a p^+n JFET. What are the frequency limiting factors of such devices? With necessary assumptions, derive the expression of unity gain cutoff frequency, f_T of such a device. (15)

SECTION – B

There are **FOUR** questions in this Section. Answer any **THREE** questions.

5. (a) With appropriate schematic diagram and energy band diagram, describe the operation of HEMT. (17)
- (b) For a HEMT, the n type $\text{Al}_{0.3}\text{Ga}_{0.7}\text{As}$ is doped to 10^{18} cm^{-3} and has a thickness of 500 \AA . The undoped spacer layer is 20 \AA . Assume $\phi_B = 0.85$ V, $\Delta E_C/q = 0.22$ V, ϵ for $\text{Al}_{0.3}\text{Ga}_{0.7}\text{As}$ is 12.2 and $\Delta d = 100 \text{ \AA}$. Find the threshold voltage for the device and also the electron concentration at $V_g = 0$. (18)

EEE 455

6. (a) Draw the equivalent circuit for basic Ebers-Moll model as used in BJT. Also find the expression for I_C and I_E as used in this model. (15)
- (b) Define f_T and f_{max} as used for transistors. Derive the expression for f_T for JFET using small signal model. (10)
- (c) Find f_T for a silicon JFET. The following parameters are given. (10)
- | | |
|--|-------------------------------|
| $\mu_n = 1000 \text{ cm}^2/\text{V-S}$ | $a = 0.6 \text{ }\mu\text{m}$ |
| $N_d = 10^{16} \text{ cm}^{-3}$ | $L = 5 \text{ }\mu\text{m}$ |
| $\epsilon_{si} = 11.7$ | |
7. (a) What is non-uniform base doping? By deriving appropriate equation show how Gummel-Poon model can take care of non-uniform base doping. (20)
- (b) What is high level injection in BJT? Describe the effects of high level injection. (15)
8. (a) Draw the cross-section schematic and energy band diagram of AlGaAs/GaAs HBT. What is the problem with this structure? How this problem can be solved? (Show with appropriate band diagram) (15)
- (b) Compare the doping profiles of homojunction and heterojunction bipolar transistor. Briefly discuss why they are different. (10)
- (c) For a HBT, it is given $\Delta E_g = 0.3 \text{ eV}$. By what factor the gain of the HBT will be more than a BJT. Assume, all other parameters for BJT and HBT are same and $T = 300^\circ \text{ K}$. (10)
-

L-4/T-1/EEE

Date : 24/09/2018

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2017-2018

Sub : **EEE 475** (Power Plant Engineering)

Full Marks : 210

Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this Section. Answer **Q. No 1** and any **Two** from the rest.

1. In context of Bangladesh-write an essay on “Technology, Economy an Environmental” for electricity generation. (35)
2. Why IC Engine based Power plants are operating in captive power generation and Grid electricity Production? Draw layout of a modern IC Engine Power Plant and mention its major components. Explain how the thermal efficiency of an IC Engine power Plant can be enhanced. (35)
3. Explain why Nuclear Power Plant is advantageous for Bangladesh Grid Power Generation. Define and explain “Safety”, “Security” and “Safe guard” in relation to a Nuclear Power Plant Construction, Operation and Maintenance. (35)
4. What is Repowering of existing Power Plant. How capacity and thermal efficiency of an operating steam Power Plant can be enhanced? Discuss with a neat diagram. (35)

SECTION – B

There are **FOUR** questions in this Section. Answer any **THREE** questions.

5. (a) Explain the following terms as applied to power system (i) Demand factor, (ii) Diversity factor, (iii) Load factor, (iv) Capacity factor, and (v) Utilization Factor. (15)
(b) What is meant by load curve? What is its significance in power generation? (10)
(c) The annual peak load on a 30 MW power station is 25 MW. The power station supplies loads having maximum demands of 10 MW, 8.5 MW, 5 MW and 4.5 MW. The annual load factor is 45%. Find (i) Diversity factor and (ii) Demand factor. (10)
6. (a) Explain the terms (i) heat rate, and (ii) incremental heat rate of a power plant. What is the significance of incremental heat rate curve? (18)
(b) The input-output curve of a 150 MW station is expressed by the formula
 $I = 10^6(250 + 5L + 0.03L^2) + L^4$ where I is in kcal per hour and L is in megawatts. Find the load at which minimum heat rate occurs. (17)

Contd P/2

EEE 475

7. Explain how economical load division is obtained between the two alternators of a power station.

Prove that for economical load sharing the incremental rates of the two are equal. Also, derive the condition for maximum efficiency. **(15+10+10)**

8. (a) Explain how load-duration and energy-load curves are derived from a chronological load curve. **(17)**

(b) Why load forecasting is necessary for economical operation of power plants? **(10)**

(c) List the factors which should be considered while designing a power plant. **(8)**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2017-2018

Sub : **EEE 435** (Optical Fiber Communication)

Full Marks : 210

Time : 3 Hours

The figures in the margin indicate full marks.

All Symbols have their usual meaning.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this Section. Answer any **THREE**.

1. (a) Define the different modes in a Multimode optical fiber. Determine the cut-off condition of a mode in a fiber. Find the expressions of normalized frequency (V) and normalized propagation constant (b) and hence plot b as a function of V for a few low-order fiber modes. Also show the single mode condition. (15)
- (b) Compare the properties of step-index SMF and graded index MMF. Which one is suitable for long haul fiber-optic communication and why? (10)
- (c) A step-index fiber has a core diameter of $7.2 \mu\text{m}$, a core index of 1.46, and a relative refractive index difference of 1%. A light of wavelength $1.55 \mu\text{m}$ is used to excite the modes in the fiber. Find the modes using the plot of Q. 1(a). Show how this fiber can be made single-mode fiber. (10)

2. (a) Make a comparison between chromatic dispersion and polarization mode dispersion. How do they affect fiber-optic communication? (10)
- (b) With necessary figure, define the different components of intramodal dispersion. Explain how intramodal and intermodal dispersion can be controlled. (12)
- (c) Draw the total dispersion characteristics of SSMF, DSF, DFF and DCF, and mention their particular applications. The material dispersion for a glass fiber is 20 ps/nm/km at a wavelength of $1.5 \mu\text{m}$. Estimate the rms pulse broadening due to material dispersion within the fiber when light is launched from an injection laser source with a peak wavelength of $1.5 \mu\text{m}$ and an rms spectral width of 2 nm into a 30 km fiber. Also calculate the bandwidth-length product approximately. Assume maximum possible bandwidth and RZ data pulses. (8+5)

3. (a) Briefly discuss different linear and nonlinear scattering losses in a silica fiber. Draw the attenuation spectra of a silica fiber showing different loss components and the operating windows for optical fiber communication. Mention few attributes of fourth generation lightwave systems. (13)
- (b) What is chirping of optical pulse? Considering a two-channel WDM system, explain with analytical expression how SPM and XPM cause chirping effect in transmitting pulse of a channel. (10)

EEE 435

Contd ... Q. No. 3

(c) Assume a 3-channel WDM system with equal channel spacing of 100 GHz. Determine the FWM products and draw the spectrum for the whole system. Now explain how FWM affects the transmitting channels. What will happen if number of channel has been increased?

(12)

4. (a) A digital fiber-optic link of length 50 km without repeater has a rated loss of 0.2 dB/km. The fiber is spliced at every 5 km which incurs a loss of 0.5 dB each. An injection laser diode is used as a transmitter which is operating at 1500 nm. The photodiode at the receiver requires an optical power of -40 dBm in order to give necessary BER of 10^{-9} . The transmitter to fiber and fiber to photodiode couplings are made of couplers of loss 2 dB each. Finally, an extinction ratio penalty of 1.5 dB is predicted for the system.

Calculate:

(18)

- (i) Total loss from transmitter to receiver,
- (ii) Minimum power (in mW) required for the laser to achieve reliable communication. It is predicted that a safety margin of 7 dB will be required, and
- (iii) Dispersion-equalization penalty if data rate is 100 Mb/s and rms pulse broadening resulting from dispersion is 100 ps/km.

(b) Write short notes on (Any Two):

(17)

- (i) FBT coupler (ii) AWG (iii) OADM

SECTION – B

There are **FOUR** questions in this Section. Answer any **THREE** questions.

5. (a) What is population inversion? How to create population inversion? (8)
- (b) What is the main problem of three-level stimulated emission? How the problem can be solved? (8)
- (c) Briefly describe the operating principle of a semiconductor laser. (10)
- (d) A GaAs injection laser has an optical cavity of length 200 μm and width 100 μm . The gain factor and the loss coefficient of the laser are 20 kA m^{-3} and 10 per cm, respectively. The refractive index of GaAs is 3.6. Determine the threshold current for the laser. (9)
6. (a) Draw the output spectra and input-output characteristics of LED and LASER. Write down the comparative advantages and disadvantages of LED and LASER. (10)
- (b) Write down a comparative overview among planar, dome, surface emitter and edge emitter LEDs. (9)
- (c) Describe the operating principle of a semiconductor optical amplifier? (8)
- (d) Explain the operating principle of an EDFA? (8)

EEE 435

7. (a) Describe the operating principles of avalanche photo diode and p-i-n photo diode. (16)

(b) Show that responsivity of an optical detector is given by $R = \frac{\eta e \lambda}{hc}$. (10)

(c) The band gap of a photo detector is 1.4×10^{-19} J. The quantum efficiency of the detector is zero or 50%. Determine the photocurrent for 1 mW optical power when the system is operating at (i) $0.79 \mu\text{m}$ (ii) $1.33 \mu\text{m}$ and (iii) $1.55 \mu\text{m}$. (9)

8. (a) Show that for an ASK heterodyne coherent receiver the current, $I_{SH} = \frac{2\eta e}{hf} \sqrt{P_s P_L}$, where the symbols have their usual meanings. (15)

(b) Calculate the repeater spacing to maintain a BER of 10^{-9} in a 2.5 Gbps coherent ASK heterodyne (synchronous) detection system operating at 1330 nm when the fiber and splice losses are 0.2 dB/km and 0.05 dB/km, respectively and the optical source launched mean power of -3 dBm. Note that $2 \times 10^{-9} = \text{erfc}(4.24)$. (11)

(c) Write short notes on WDM, MZM and PON. (12)

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2017-2018

Sub : **EEE 433** (Microwave Engineering)

Full Marks : 210

Time : 3 Hours

The figures in the margin indicate full marks.

Symbols have their usual meaning, Assume reasonable values if any data is missing.

USE SEPARATE SCRIPTS FOR EACH SECTION

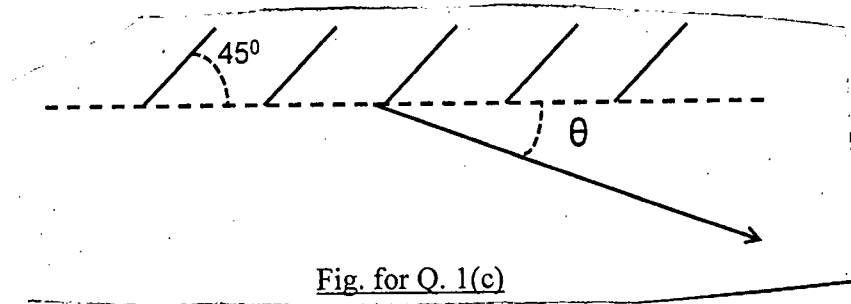
SECTION – A

There are **FOUR** questions in this Section. Answer any **THREE**.

1. (a) "Antenna is needed for two main reasons: (i) efficient radiation and (ii) matching wave impedances"-Explain this statement with relevant example(s). Is Hertzian dipole a good antenna? If yes/no, why? (8)

- (b) Write down the steps how you will calculate the radiated fields of any wire antenna? (7)

(c)



For a five element half-wave dipole array shown in figures for Q. No. 1(c), the following information are given,

The array is located directly on an infinite ground plane with the elements tilted 45° as shown, the elements are fed with uniform current and 30° phase progression, inter element distance is $\lambda/4$, each dipole is 4 cm long, θ is the elevation angle to be employed in the calculation.

Now, calculate the following:

(20)

- (i) Array factor
- (ii) Unit **E**-field pattern
- (iii) Total **E**-field pattern

Also, draw normalized unit pattern, group pattern and total pattern for **E**-field in the $\Phi = \pi/2$ plane.

2. (a) Derive the FRIIS transmission equation. (9)

(b) Two half-wave dipole antennas are operated at 100 MHz and separated by 1 km. If 80 W is transmitted by one, how much power is received by the other? Let, $G_{dt} = G_{dr} = 1.64 \sin^2\theta$.

The receive antenna is at $\theta = 30^\circ$ with respect to the transmit antenna and the receive antenna is oriented such that it can receive maximum power from the transmit antenna. (9)

Contd P/2

EEE 433

Contd ... Q. No. 2

(c) The general pattern function of an aperture radiator is given by. (17)

$$F(\theta, \phi) = \iint_{\text{aper.}} E_a(x', y') e^{j\beta \sin\theta(x' \cos\phi + y' \sin\phi)} dx' dy'$$

Now, consider a rectangular aperture. The aperture dimensions are $7.5 \times 5 \text{ cm}^2$. The aperture is fed by a hollow rectangular waveguide's TE_{10} mode only. Based on these info, calculate the following:

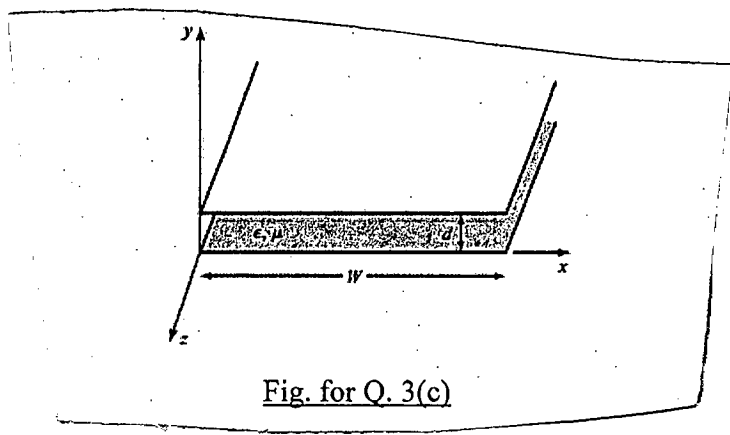
- (i) The frequency of the radiated field,
- (ii) Pattern function in the $\Phi = 0$ plane,
- (iii) The half-power beamwidth.

3. (a) Derive from the Maxwell's equations, the general field solutions for TE and TM modes in a transmission line or waveguide. Assume the wave propagation along the z-axis of Cartesian coordinate system. (15)

(b) For a parallel plate waveguide, explain the reason why the TM_0 mode is actually identical to the TEM mode. (5)

(c) In Fig. 3(c), $d = 2 \text{ cm}$, $\epsilon = 2\epsilon_0$. Now, (15)

- (i) Calculate the cutoff frequencies and propagation constants of the first two modes other than TEM.
- (ii) Calculate the average power propagated through the waveguide using the TM_1 mode. Assume the peak value of E -field is 65 V/m and $W = 5 \text{ cm}$. Ignore the presence of fields beyond the cross-sectional area $W \times d$.



4. (a) A circular waveguide has a radius of 0.4 cm and is filled with a dielectric material with $\epsilon_r = 1.5$ and $\tan\delta = 0.0002$. Identify the first four propagating modes and their cutoff frequencies. For the dominant mode, calculate the dielectric loss (attenuation). (17)

n	P'_{n1}	P'_{n2}	P'_{n3}
0	3.832	7.016	10.174
1	1.841	5.331	8.536
2	3.054	6.706	9.970

Fig. for Q. 4(a) : for TE modes

n	P_{n1}	P_{n2}	P_{n3}
0	2.405	5.520	8.654
1	3.832	7.016	10.174
2	5.135	8.417	11.620

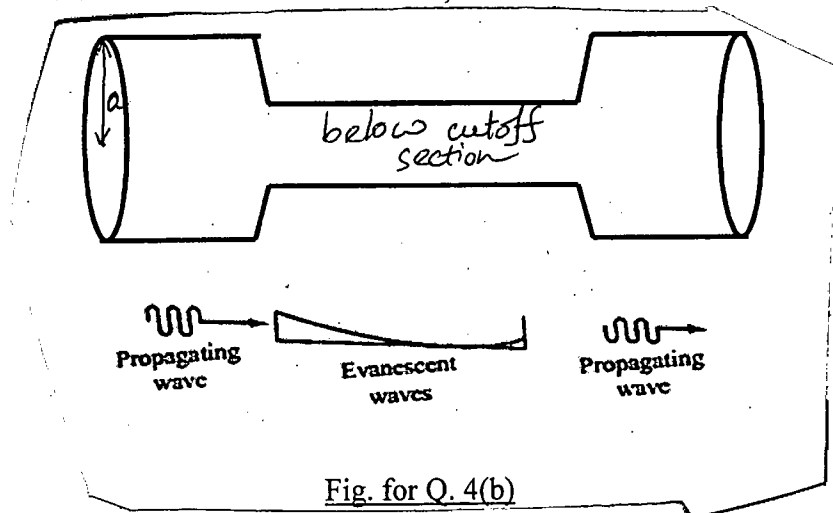
Fig. for Q. 4(a) : for TM modes

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Contd ... Q. No. 4

(b) An attenuator can be made using a section of waveguide operating below cutoff, as shown in Fig. for Q. 4(b). For this air-filled circular waveguide, if the radius of the bigger section is $a = 2.54$ cm and the operating frequency is 4 GHz, determine the length required of the below-cutoff section of the circular waveguide to achieve an attenuation of 100 dB between the input and output guides. Ignore the effect of reflections at the step discontinuities and assume PEC boundaries. Given, the radius of the below cutoff section is

$$\frac{a}{2}$$



(18)

Fig. for Q. 4(b)

SECTION – B

There are **FOUR** questions in this Section. Answer any **THREE** questions.

5. (a) Using necessary diagrams derive the one-dimensional wave equations of voltage and current for a two conductor transmission line. (10)

(b) For sinusoidal voltage on ideal transmission line prove that,

$$Z_i = Z_0 \left[\frac{Z_L \cos \beta l + jZ_0 \sin \beta l}{Z_0 \cos \beta l + jZ_L \sin \beta l} \right] \quad (10)$$

where symbols have their usual meaning.

(c) Consider the transmission line given in Fig. for Q. 5(c). Given that: $f = 18$ GHz, $Z_L = 20 \angle 0^\circ$ ohm, $Z_{01} = 20$ ohm, $Z_{02} = 30$ ohm, $l_1 = 1.5$ mm, $l_2 = 2.0$ mm. Assume that the phase velocity of the signal in both lines is same which is equal to 2×10^8 m/s. Determine the input impedance Z_i of the line. (15)

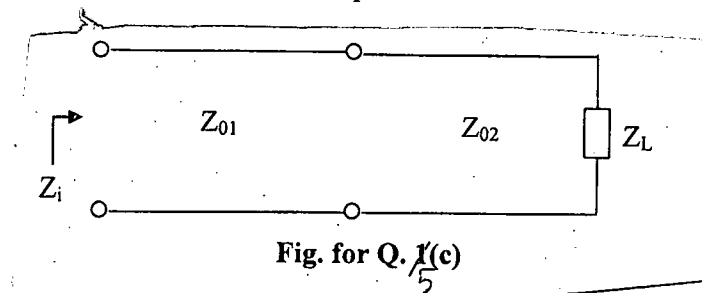


Fig. for Q. 5(c)

6. (a) With proper diagrams derive and explain the equations of constant resistance and reactance curves of the Smith transmission line chart. (18)

(b) Suppose an ideal transmission line with $Z_0 = 80$ ohm is 30 m long and operates at 2 MHz signal frequency with a phase velocity 1.8×10^8 m/s. The line is terminated with a load $Z_L = 60 + j75$ ohm. Using Smith transmission line chart determine input impedance Z_{in} of the line (Smith transmission line chart is supplied). (17)

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7. (a) For a low loss high frequency line derive the equations for attenuation constant, phase constant and characteristic impedance. Also, derive the expressions of attenuation and phase constants for a distortionless line. (10+5)

(b) What is quarter wave transformer in relation to two conductor transmission line? With necessary diagrams show that to match a line with characteristic impedance of Z_0 to a load resistance R_L the quarter wave transformer line must have characteristic impedance equal to $\sqrt{Z_0 R_L}$. (10)

(c) A single generator is to feed equal power through a lossless transmission line with a characteristic impedance of 70 ohm to two separate resistive loads, 60 ohm and 80 ohm. Quarter wave transformers are used to match the loads to 70 ohm line. Determine the required characteristic impedance of the quarter wave lines. Find the standing wave ratios on the matching line sections. (10)

8. (a) For TE_{10} wave in a rectangular waveguide, (18)

$$\begin{aligned}
 H_z &= A_{10} \cos \frac{\pi x}{a} e^{-j\beta z} \\
 E_y &= \frac{-j\omega\mu a}{\pi} A_{10} \sin \frac{\pi x}{a} e^{-j\beta z} \\
 H_x &= \frac{j\beta a}{\pi} A_{10} \sin \frac{\pi x}{a} e^{-j\beta z} \\
 E_x &= E_z = H_y = 0
 \end{aligned}$$

From these equations show that, the attenuation constant for conductor loss can be given as,

$$\alpha_c = \frac{R_s}{a^3 b \beta k \eta} (2b\pi^2 + a^3 k^2) N_p/m; \text{ where symbols have their usual meaning.}$$

(b) For a Hertzian dipole of length dl carrying a uniform current $I = I_0 \cos \omega t$, the far field parameters are: (10)

$$\begin{aligned}
 H_{\phi s} &= \frac{jI_0 \beta dl}{4\pi r} \sin \theta e^{-j\beta r} \\
 E_{\theta s} &= \eta H_{\phi s} \\
 H_{rs} &= H_{\phi s} = E_{rs} = E_{\phi s} = 0
 \end{aligned}$$

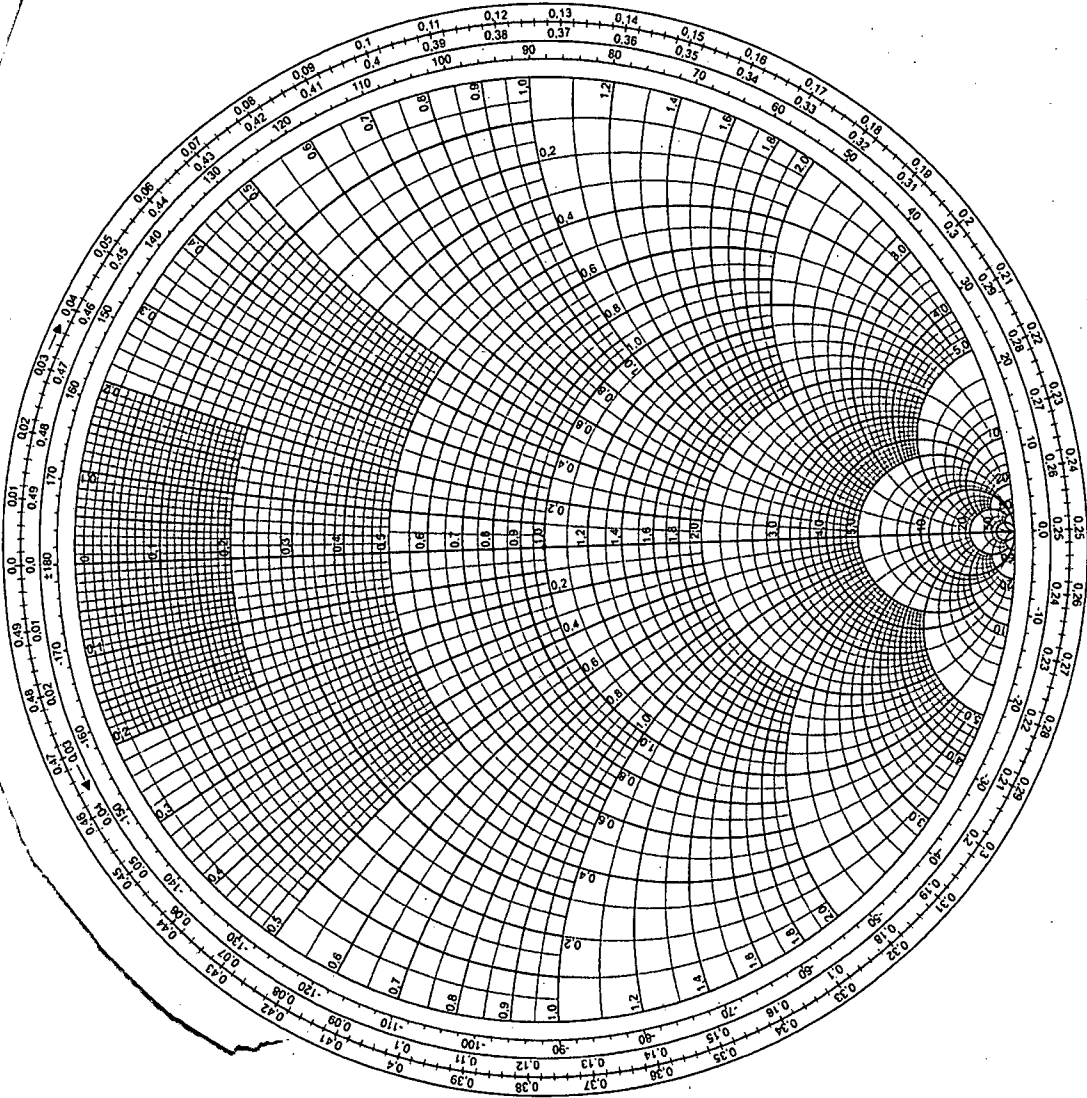
From these equations show that for free space propagation, $P_{rad} = 40\pi^2 \left[\frac{dl}{\lambda} \right]^2 I_0^2$, where the symbols have their usual meaning.

(c) Determine the electric field intensity at a distance of 10 km from an antenna having a directive gain of 6 dB and radiating a total power of 20 kW. (7)

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= 5 =

Smith's Transmission Line Chart
(Please attach this chart with your answer script)



BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B.Sc. Engineering Examinations 2017-2018

Sub : **EEE 453** (VLSI I)

Full Marks: 210

Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

SECTION – AThere are **FOUR** questions in this section. Answer any **THREE**.

Symbols and abbreviation have their usual meanings.

1. (a) With necessary figures, explain what happens to the transfer characteristics curve and noise margins NM_L and NM_H when β_p/β_n is increased in a CMOS inverter pair. Assume that the logic levels are selected at the unity gain points of the DC transfer characteristic curve to maximize the noise margin. (15)
- (b) Sketch a 3-input NOR gate at MOS transistor level with transistor widths chosen to achieve effective rise and fall resistance (R) equal to a unit inverter in the worst case. Calculate the rising propagation delay (t_{pdr}), falling propagation delay (t_{pdf}), rising contamination delay (t_{cdr}) and falling contamination delay (t_{cdf}). Assuming that the NOR gate is driving h number of similar gates and $\mu_n = 2\mu_p$. (20)
2. (a) A 1 billion transistor chip is to be fabricated in 1.2 V 50 nm process. There are 200 million logic transistors with average width of 12λ and activity factor of 0.1. The remaining are memory transistors with average width of 4λ and activity factor of 0.02. The gate capacitance is $1\text{fF}/\mu\text{m}$ and diffusion capacitance is $0.8\text{fF}/\mu\text{m}$. Estimate the dynamic power consumption at 2 GHz. Neglect wire capacitance and short circuit current. (17)
- (b) Explain with necessary figure how clock gating can be used to reduce dynamic power. (9)
- (c) Explain with necessary figure how sleep transistors can be used to reduce static power consumption. What should be the size of the sleep transistors so that performance is not degraded? What is the adverse effect of choosing such size of transistors? (9)
3. (a) Draw the schematic diagram of a master-slave flip flop using inverters and CMOS transmission gates only and briefly explain its operation. (8)
- (b) A buffer chain is to be designed for a clock signal which will drive 1500 logic gates. The input capacitance of each of the logic gates is 8 pF and the output capacitance is 3 pF. The minimum sized inverter in the process has an input capacitance of 4 pF and output capacitance is 2 pF. Find the size (n) and the number of stages (m) of the required buffer chain. You have to derive the equations used in your calculation first. (12)

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Contd... Q. No. 3

(c) Consider the design of a CMOS compound AND-AND-OR-INVERT (AOI22) gate computing $F = \overline{(A.B) + (C.D)}$. (15)

- (i) Sketch a transistor level schematic diagram suitable for drawing in the stick diagram.
- (ii) Sketch a stick diagram corresponding to the schematic diagram.
- (iii) Estimate the minimum area from the stick diagram.

4. (a) Show in diagram the origin and model of COMS latch up in a PWELL process. How can latch up be prevented? (8)

(b) Two resistors each having 4 unit resistors are to be matched in a layout. The sheet resistance varies linearly as a function of position. Between interdigitated layout and common centroid layout which one will you prefer for matching? Justify your answer with numerical values. (7)

(c) Sketch a 3-input NAND gate with transistor widths chosen to achieve worst case rise and fall resistance equal to a unit inverter. Let C and R be the gate/diffusion capacitance and resistance, respectively of a unit NMOS transistor ($W_n = W_{min}, L_n = L_p = L_{min}$). Assume $\mu_n = 2\mu_p$ and that standard layout practice was followed. Assume that for merged uncontacted diffusion, the output capacitance is $\frac{1}{2}C$ and for shared contacted diffusion the output capacitance reduces by 2C. (20)

- (i) Show the layout of the above NAND gate.
- (ii) Sketch the transistor level schematic of the gate. In the schematic back annotate the capacitance at each node of the circuit as calculated from the layout.
- (iii) Compute the worst case rising and falling propagation delay (t_{pdr} and t_{pdf}) and best case rising and falling contamination delay (t_{cdr} and t_{cdf}) of the NAND gate driving h identical NAND gate using Elmore delay model.
- (iv) If $C = 1 \text{ fF}/\mu\text{m}$ and $R = 1.25 \text{ k}\Omega/\mu\text{m}$ in 65 nm process determine $t_{pdr}, t_{pdf}, t_{cdr}$ and t_{cdf} of the above fan out of 3 NAND gate.

SECTION-B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) Explain with necessary timing diagram why it is illegal for one dynamic gate to drive another dynamic gate. (6)

(b) Draw the layout diagram of a 4 to 1 mux implemented by CMOS transmission gate to perform the function of a 2 input – NOR gate. (9)

(c) Show the transistor level implementation of the following logic function in a CMOS NOR-NOR programmable logic array (PLA) (20)

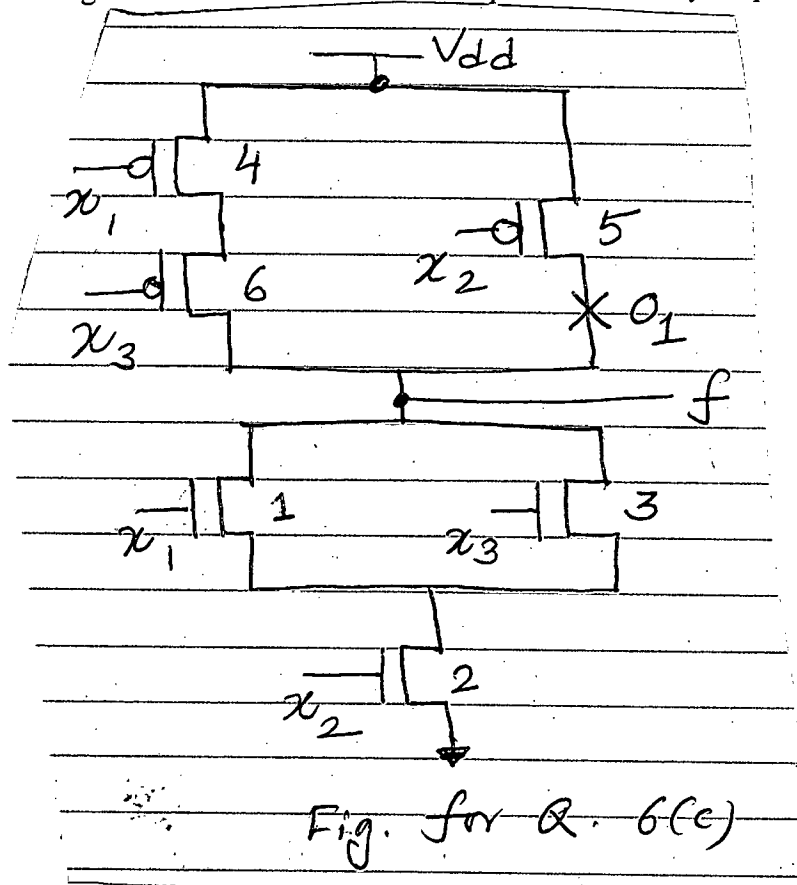
$$z_1 = \overline{ab} + \overline{cd}$$

$$z_2 = \overline{ab} + ce$$

$$z_3 = \overline{cd}$$

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6. (a) Design an n-bit parity generation circuit in bit sliced and structured way. The required response is such that $Z=1$ if there is odd number of ϕ 's in the input and $Z = \phi$ if there is even number of ϕ 's. Show the block diagram of the parity generator including the connection of the first cell. Draw the layout diagram of the leaf cell using CMOS technology in a modular way such that interconnection between cells are achieved when cells are butted to-gather. (12)
- (b) Draw the schematic diagram of a 4x4 barrel shifter and explain what happens when 2 bit right shift signal is applied. (5)
- (c) In the Fig. for Q. 6(c), transistor 5 is stuck open (O_1). Find all the two pattern test vectors that will detect the fault. (9)
- (d) Draw the circuit diagram of a bi-directional I/O pad and briefly explain its operation. (9)



7. (a) A sequence detector produces a '1' for each occurrence of the input sequence '0011' at its input. Draw the state-transition diagram of the Finite State Machine (FSM) realizing the sequence detector. Obtain the state table and state assigned table from the state transition diagram. Realize the FSM using D Flip Flop and combinational logic. (20)
- (b) Write the verilog code for synthesizing the sequence detector in Question 7(a). (15)
8. (a) Explain how ALU functions in (i) addition, (ii) subtraction, (iii) AND (iv) OR, (v) EX-OR and (vi) EX-NOR can be implemented with an adder. Show the arrangement for a 4-bit ALU. (18)
- (b) Draw the circuit diagram of a 2x2 bit six transistor Static Random Access Memory (SRAM) array. Show clearly the row select, column select, pre-charge, sense amplifier and the I/O signal lines. Explain how 'write' operation is performed. (17)

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2017-2018

Sub : **EEE 473** (Power Electronics)

Full Marks : 210

Time : 3 Hours

The figures in the margin indicate full marks.

Symbols have their usual meaning, Assume reasonable values if any data is missing.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this Section. Answer any **THREE**.

1. (a) For a single phase full bridge controlled rectifier, for continuous conduction in output current, show that the average output voltage is given by

$$V_{dc} = \frac{2V_m}{\pi} \cos \alpha \quad (15)$$

Where V_m is the peak magnitude of the input sinusoidal supply voltage and α is the firing angle.

- (b) A 12 V dc battery is charged through a single phase full bridge controlled rectifier from a 240/15 V transformer. The supply frequency is 50 Hz and supply voltage is 230 V (RMS). Determine the firing angle of the converter if the average charging current is to be 10A (consider a series resistance of 0.15 Ω in the charging circuit). Also determine the minimum volt-ampere rating of the transformer. (20)

2. (a) Derive an equation for the average (dc) voltage output of a 3-phase full bridge controlled rectifier as a function of the peak phase voltage and firing angle α . (15)

- (b) A 10 kW, 400 Vdc shunt motor is run from a 3-phase dual converter. The armature resistance (including brush drop) is 0.12 Ω . If the motor runs at full load (10 kW) at rated speed with a back EMF of 395 Vdc, determine the firing angle of the converters. (20)

3. (a) Draw a single phase H-bridge inverter and explain its operation with necessary gating signals and output waveforms considering an R-L load and operating in square wave mode. (15)

- (b) An on-line UPS is supplied from 8 numbers of 12 V dc batteries connected in series and has an Hi-bridge inverter topology. The inverter is controlled using sine pulse width modulation technique. The UPS has a 90 V/250 V transformer that interfaces the inverter and the load. If the load needs a voltage of 300 V peak at a sinusoidal output frequency of 50 Hz, determine the index of modulation of the inverter control (neglect losses in the inverter switches and consider an R-L load with very low power factor). (20)

4. (a) For an inverter controlled with sine pulse width modulation, show that the peak output voltage V_m is related to the input supply voltage V_s by the equation $\frac{V_m}{V_s} = \frac{A_m}{A_c}$ where A_m is

the peak magnitude of the reference sinusoidal waveform and A_c is the peak magnitude of the triangular carrier waveform. (17)

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Contd ... Q. No. 4

(b) Draw a 3-phase full-bridge VSI topology and explain its controls for 3-phase stepped output voltage generation considering star connected load. Choose either 180° or 120° conduction mode of operation. (18)

SECTION – B

There are **FOUR** questions in this Section. Answer any **THREE** questions.

5. (a) Describe SCR I-V characteristics. Define holding current and latching current. (10)

(b) What is natural commutation and forced commutation in SCR? Explain (i) self commutation and (ii) complementary commutation with suitable examples. Draw necessary waveforms for your explanation. (13)

(c) For a single phase AC-AC voltage controller with resistive load find the equation of Input Power Factor in terms of firing angle 'α'. (12)

6. (a) Draw the circuit diagram of a three phase voltage controller. Assume that, the gate pulses are fired at $\alpha = 90^\circ$ and the span of each gate pulse is 180° (extended gate pulse). Draw the waveforms of line to neutral voltages across a three phase resistive load with proper calculations. (25)

(b) Draw the circuit diagram of a three phase to single phase cycloconverter and show the gate pulses applied for two cycles of input voltage. (10)

7. (a) For infinitesimal variation in duty cycle, find the transfer function, $T(s) = \frac{V_0(s)}{d(s)}$ for a Buck DC-DC converter. Assume that input voltage remains constant. (17)

(b) Design a Buck Converter for specifications given below: (18)

Input voltage, $V_{in} = 12$ V

Output voltage, $V_0 = 5.2$ V

Load = 2A, 10.4 W

Maximum Output Voltage Ripple = 5%

Minimum Inductor Current = 90% of average inductor current.

Switching frequency = 150 kHz

Specify the withstand capability required for each switch, inductor value, filter capacitor value.

8. (a) Draw the circuit diagram of a Ĉuk dc-dc converter and explain its operation showing the path of current flow when the switch is ON and when the switch is OFF. Derive the relation between input and output voltages. (17)

(b) For a Ĉuk converter find the minimum values of inductors required to keep the operation in Continuous Conduction Mode. (12)